Murdoch
UNIVERSITY

Herrington, J. , Reeves, T.C. and Oliver, R. (2007) Immersive learning technologies: Realism and online authentic learning. Journal of Computing in Higher Education, 19 (1). pp. 80-99.

http://researchrepository.murdoch.edu.au/5241

Immersive learning technologies: Realism and online authentic learning

AUTHORS:

Jan Herrington
Faculty of Education
University of Wollongong, Australia
jan_herrington@uow.edu.au

Thomas C. Reeves
College of Education
The University of Georgia, Georgia, USA
treeves@uga.edu

Ron Oliver
School of Communications and Multimedia
Edith Cowan University, Australia
r.oliver@ecu.edu.au

CONTACT AUTHOR:

Jan Herrington
Faculty of Education
University of Wollongong,
New South Wales, Australia, 2522
Email: jan_herrington@uow.edu.au
Phone: +612 4221 4277

Immersive learning technologies: Realism and online authentic learning

Abstract:

The development of immersive learning technologies in the form of virtual reality and advanced computer applications has meant that realistic creations of simulated environments are now possible. Such simulations have been used to great effect in training in the military, air force, and in medical training. But how realistic do problems need to be in education for effective learning to occur? Some authors and researchers argue that problems should be real, or that simulations should have ultra-realistic physical similarity to an actual context. This paper proposes that physical verisimilitude to real situations is of less importance in learning than 'cognitive realism', provided by immersing students in engaging and complex tasks. The paper presents a description of the theory and research that provide the foundations for this approach. Examples of courses employing cognitive, rather than physical, realism are presented together with the views of teachers, authors and instructional designers. Finally, the implications of this approach are discussed.

Immersive learning technologies: Realism and online authentic learning

Introduction

Throughout history, people have attempted to escape the real world by surrounding themselves with more appealing representations of reality. The artistic representation of realistic landscapes has existed at least since the Hellenistic Greeks with the development of perspective in art, which allowed the placement of objects in 'believable space' (Greenhalgh, 2002, p. 2). Affluent citizens of Greece surrounded themselves with panoramic landscapes on the walls of their rooms, representing idyllic scenes. The artists worked to make these panoramas as realistic as possible to allow the occupants of the rooms to experience an alternative reality. As skills with portraying perspective in art developed during the Renaissance, trompe l'oeil ('the art of deception') paintings became increasingly popular, providing viewers with a more appealing visual aspect than reality would permit within available time and space.

Since the development of factory model schools (Rist, 1973), reality and real-world practice have been insufficiently used to convey meaning or alternative views in traditional classrooms, much to the detriment of learners. For example, the physicist Murray Gell-Mann proposed that 'education in the 20th century is like being taken to the world's greatest restaurant and being fed the menu' (cited in Kay, 1991). According to Kay 'representations of ideas have replaced the ideas themselves' (Kay, 1991). Even in higher education contexts where arguably there are numerous opportunities to providing learning opportunities beyond the walls of the lecture hall, teaching has largely been limited to abstract talk, text, and tests.

Fortunately, in the last decade or more, under the influence of constructivist philosophy (Fosnot, 2005) and approaches such as situated learning (Brown, Collins, & Duguid, 1989), anchored instruction (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990) and problem-based learning (Barrows & Tamblyn, 1980), many instructors in colleges and universities have tried to make learning more relevant to students by creating opportunities for them to apply their learning in realistic, if simulated, situations. Service learning, co-ops, internships, apprenticeships, and other strategies have been used to expand learning options for postsecondary students. At the same time, many instructors have attempted to use technology such as computers and video to recreate the essence of real situations in order to design authentic learning experiences for students.

Immersive learning and virtual reality

In recent years, simulations have become popular in industry and retail areas such as in building construction scheduling, architecture, interior design and landscaping (Green & Sulbaran, 2006) where the facility to create an immersive three-dimensional representation of ideas can have obvious benefits for planning, evaluation, marketing, and training. Rosenberg (2006) promotes the potential of interactive simulations for learning:

> Through the power and creativity of simulations and the ubiquitous nature of the Internet, scenarios can be created that rival the real world, making training more relevant, more effective, more challenging, and, where appropriate, more fun. Indeed, technology-based games and simulations represent one of the fastest growing segments of the e-learning industry, and the US government is now fully engaged in simulations and games, even for highly sensitive areas like the military and homeland security. (pp. 47-48)

Indeed, the United States space program, the airline industry, the military, and medical schools have a long history of using simulations to provide learning situations with high degrees of verisimilitude to real life environments. The US space program uses highly realistic, computer generated simulations to train astronauts to cope with highly critical situations. Murray and Cox (1989) described the total realism of the simulations used to train astronauts on the Apollo missions, and how mission controllers were able to relate fully to situations simulated in training, with perhaps the exception proving the rule. The following quote describes a mission controller's response to the presence of dust on a real mission on the moon (something that was not included in the simulations):

> It was then he heard Aldrin in Eagle say 'Forty feet down, two and a half, picking up some dust'. Garman was startled out of his trance. Everything had felt just like

> the simulations until then. But Aldrin had never said ‘Picking up some dust’. The image of the dust blowing up … made it real, and the enormity of it began to sink in. (Murray & Cox, 1989, cited in Murnane, 2000, p. 355)

Virtual reality technology enables simulations so realistic in aircraft training that people react spontaneously and automatically to the environment as if they were really experiencing it. For example, McLellan (1991) related a trainee pilot’s experience in an aircraft simulator:

> Part of the drill is that we lose an engine at a critical period in the take-off. And I made the rotation and I did everything I possibly could and the thing rolled to the right and crashed ... I yelled and everybody else yelled ... It is so realistic that it’s almost frightening (p. 33).

Macedonia and Rosenbloom (2001) described collaboration among the military, academia and Hollywood to create realistic and immersive simulations for military training. Maximum verisimilitude to genuine combat and other situations is required. The simulation described by Macedonia and Rosenbloom was designed to be used for training soldiers about to engage in combat or peace-keeping missions in foreign countries. This simulation includes a full briefing on the mission, weapons, political factions, strategies and immersion in the culture of the city. Describing the experience of a soldier in this simulation, Macedonia and Rosenbloom wrote: ‘The sights, sounds and smells of the city immediately bombard him … the scene is a rich and confusing tapestry of life’ (p. 90). The elements of real life situations are included to ensure that soldiers can account for peripheral events sometimes not accounted for in training situations.

In medicine, patient simulators that allow students to practice procedures under realistic conditions on simulated patients have created many opportunities for early skill development prior to practice on real patients. For example, at Harvard Medical School, a simulator for practising bronchoscopy is used whereby a flexible fiberoptic bronchoscope is ‘snaked’ down the trachea to inspect the airways leading to the lungs. The director of the program stated that: ‘The tissues look real, even seem to move when touched. The simulator patient breathes and has a heartbeat; he coughs if the user hits an airway wall’ (Rabkin, 2002).

What are the characteristics of such simulations that enable realistic fidelity to the genuine situation and provide valuable training and preparation for the real situation? Macedonia and Rosenbloom (2001) proposed that there are ‘six thrusts crucial to verisimilitude’ that are worthy of further investigation and research:

1. Immersion: providing compellingly realistic experiences
2. Networking and databases: organizing, storing, and distributing content
3. Story: providing compelling interactive narratives that propel experiences
4. Characters: replacing human participants with automated ones
5. Setup: authoring and initializing environments, models, and experiences
6. Direction: monitoring, directing, and understanding experiences (p. 86).

Realistic or real?

Simulations based on design criteria such as the six listed above, with full plot development and character representation may be effective in certain learning situations. They are, however, extremely resource intensive and expensive to develop. They also have certain limitations implicit in their development, such as predetermined outcomes that need to be predicted and created within the parameters of the scenario itself. How real does a learning environment need to be to ensure quality learning outcomes? Some argue that only a real problem situation should be presented, with no simulation at all. For example, Savery and Duffy (1996) nominated two guiding forces in developing problem-based scenarios: firstly, that the problems must raise the concepts and principles relevant to the content domain, and secondly that the problems must be real. They stated:

> There are three reasons why the problems must address real issues. First, because the students are open to explore all dimensions of the problem there is real difficulty of creating a rich problem with a consistent set of information. Second, real problems tend to engage learners more—there is a larger context of familiarity with the problem. Finally, students want to know the outcome of the problem—what is being done about the flood, did AT&T buy NCR, what was the

problem with the patient? These outcomes are not possible with artificial problems. (Savery & Duffy, 1996, p. 144)

Is it necessary then, when incorporating authentic learning experiences into learning environments, to design totally real or highly realistic simulations? Is the physical or simulated reality of a learning situation a critical component of effectiveness? Research into the realism of learning environments indicates that maximum fidelity does not necessarily lead to maximum effectiveness in learning, particularly for novice learners (Alessi, 1988). Smith (1987) in his review of research related to simulations in the classroom concluded that the 'physical fidelity' of the simulation materials is less important than the extent to which the simulation promotes 'realistic problem-solving processes' (p. 409), a process Smith describes as the 'cognitive realism' of the task (Smith, 1986). Our own research proposes that the physical reality of the learning situation is of less importance than the characteristics of the task design, and the engagement of students in the learning environment.

Our current research has sought to investigate examples of courses or units that use authentic tasks as a framework for the completion of entire semester courses, or large sections of them. Instead of using a delivery system where courses are divided into weekly segments of content, and students complete readings and assignments as course requirements, we have investigated courses where the completion of sustained and complex tasks comprise the course requirements and provide an effective framework and rationale for learning. Ten characteristics of authentic activities have been distilled from a review of papers on authentic learning environments from the literature on situated learning, anchored instruction and problem-based learning (c.f. Herrington, Reeves, Oliver & Woo, 2004):

1. *Authentic activities have real-world relevance:* Activities match as nearly as possible the real-world tasks of professionals in practice rather than decontextualized or classroom-based tasks (e.g., Brown, Collins, & Duguid, 1989; Cognition and Technology Group at Vanderbilt, 1990; Jonassen, 1991; Lebow & Wager, 1994; Oliver & Omari, 1999)
2. *Authentic activities are ill-defined, requiring students to define the tasks and sub-tasks needed to complete the activity:* Problems inherent in the activities are ill-defined and open to multiple interpretations rather than easily solved by the application of existing

algorithms. Learners must identify their own unique tasks and sub-tasks in order to complete the major task (Cognition and Technology Group at Vanderbilt, 1990; Lebow & Wager, 1994)

3. *Authentic activities comprise complex tasks to be investigated by students over a sustained period of time:* Activities are completed in days, weeks and months rather than minutes or hours, requiring significant investment of time and intellectual resources (e.g., Bransford et al., 1990; Jonassen, 1991; Lebow & Wager, 1994)
4. *Authentic activities provide the opportunity for students to examine the task from different perspectives, using a variety of resources:* The task affords learners the opportunity to examine the problem from a variety of theoretical and practical perspectives, rather than a single perspective that learners must imitate to be successful. The use of a variety of resources rather than a limited number of preselected references requires students to detect relevant from irrelevant information (e.g., Bransford et al., 1990; Sternberg, Wagner, & Okagaki, 1993)
5. *Authentic activities provide the opportunity to collaborate:* Collaboration is integral to the task, both within the course and the real world, rather than achievable by an individual learner (e.g., Gordon, 1998; Lebow & Wager, 1994; Young, 1993)
6. *Authentic activities provide the opportunity to reflect:* Activities need to enable learners to make choices and reflect on their learning both individually and socially (e.g., Gordon, 1998; Myers, 1993; Young, 1993)
7. *Authentic activities can be integrated and applied across different subject areas and lead beyond domain-specific outcomes:* Activities encourage interdisciplinary perspectives and enable diverse roles and expertise rather than a single well-defined field or domain (e.g., Bransford et al., 1990; Jonassen, 1991)
8. *Authentic activities are seamlessly integrated with assessment:* Assessment of activities is seamlessly integrated with the major task in a manner that reflects real world assessment, rather than separate artificial assessment removed from the nature of the task (e.g., Herrington & Herrington, 1998; Reeves & Okey, 1996; Young, 1995)
9. *Authentic activities create polished products valuable in their own right rather than as preparation for something else:* Activities culminate in the creation of a whole product rather than an exercise or sub-step in preparation for something else (e.g., Barab, Squire, & Dueber, 2000; Duchastel, 1997; Gordon, 1998)

10. *Authentic activities allow competing solutions and diversity of outcome:* Activities allow a range and diversity of outcomes open to multiple solutions of an original nature, rather than a single correct response obtained by the application of rules and procedures (e.g., Bransford et al., 1990; Duchastel, 1997; Young & McNeese, 1993).

Investigating cognitive realism in online courses

Using these criteria for the selection of appropriate courses to study, our research investigated the characteristics of authentic activity that facilitate a whole course unit of study being encapsulated within complex tasks, and to determine the factors that contribute to the successful adoption and implementation of activity-based online course units. We used the criteria listed to identify web-based courses of study that used authentic activities and tasks as a central core of their design.

In our findings to date, it has become apparent that because the central task or activity is the vehicle for study of the entire course, its design must incorporate a range of complex facets and options to enable and motivate students to learn from its completion. Many of the authors and instructors of the courses investigated have chosen a scenario in which to anchor the task. However, none of the cases are real (at least in the sense proposed by Savery & Duffy, 1996), nor do they comprise complicated plots and well-defined characters, or anticipate selected outcomes (in the way proposed by Macedonia & Rosenbloom, 2001). Some use navigation between spaces or 'rooms', some have characters to assist or to be used in vicarious roles, and some use video and graphics. But none of the environments have a verisimilitude approaching virtual reality. Instead they aim to provide a 'cognitive realism' rather than reality itself. Some of the courses investigated in the study of authentic tasks are described briefly below:

- In a semester course on North American fiction, students study novels written by writers such as Melville, Hemingway, DeLillo, Vonnegut, Atwood, and Esquival. In the course, they are given the role of Editorial Board Members of an online scholarly journal, to which they submit book reviews and articles based on their study of the literature. The teacher of the course is the journal editor, and an edition of the journal is published online at the end of the semester.

- In a course on coastal and marine systems, it is proposed that a marina be developed, and as part of the approval, annual monitoring of water quality is required. The students are provided with a set of real data collected by the course teachers from inside and outside the marina, and they are required to understand, analyse and interpret the data and draw conclusions as to whether the water quality within the marina is different to that outside, and if so explain the possible causes.

- In a course on business writing, students learn business communication skills by accepting temporary employment in a virtual recording company. They are given a complex task to complete, where they need to prepare a report on whether the company would benefit from the introduction of an internal newsletter. In order to complete this activity, they make appointments, keep a diary, 'interview' the director and other employees, and write letters and memos as required.

- In an introductory biology course for online delivery, students investigate a simulation of the discovery of new life forms, where they are given a role as biologist on an expedition to a remote lake in Siberia where several microorganisms are found that cannot be classified. They 'collect' the specimens and return to the university to analyse them. Students are assigned to groups where they analyse the specimens and prepare a report.

- In a course on qualitative and quantitative research methodologies*,* students work virtually in a graduate research centre where they are given the task of investigating the closure of a rural school. They do this using both qualitative and quantitative methods, and they are assisted by two virtual researchers who have collected data from the community and assembled it in a raw form in the centre. The students can examine school records, population data, interviews with teachers, parents and community members, newspaper reports and other documents. Students produce a report that analyses the impact of the closure of the school on the rural community.

The learning environments studied have varying degrees of fidelity to reality, but all have strong linkage to real-world professional practice, and to the 'cognitive realism' described by Smith (1986). The scenarios are not drawn in elaborate, resource intensive ways, but are built up through the creation and development of realistic and engaging ideas. Teachers, authors, instructional designers, tutors and others associated with the design and delivery of the courses were interviewed, and the websites analysed. The analysis focused on the identification of conceptual themes and issues emerging from the data, using techniques such as clustering, and making contrasts and comparisons (Miles & Huberman, 1994).

Findings of the study

In terms of the physical reality of the learning environments, few respondents considered this to be an important factor. From the simple consideration of logistics and cost effectiveness, one teacher (pseudonyms used) pointed out the benefits of not using a real situation:

> I've come to the conclusion that a simulated town [in the scenario] is just as good as being there … to take students to [a real town] would be horrifically hard to organize and I think providing something like this is just as good, and a lot more manageable. (Interview with Tracey)

An instructional designer commented that fidelity was not a paramount factor in the design of the learning problem, and that neither reality nor simulated reality was necessary for effective engagement:

> [We] very deliberately didn't try, to make total … simulation out of it. There is so much suspension of disbelief required, but the point was, there just had to be enough to get them engaged.' (Interview with Carlo)

The ability to engage students appeared to be of far greater importance in creating a sense of a realistic and worthy task than the recreation of a faithfully realistic simulation:

> Things can be real world without being engaging. Working in an industrial riveting shop is real world but is not very engaging. I think engagement of students is critical. (Interview with Camille)

One teacher was amused by students' responses to the country town that had been created for the simulation. While consisting only of graphics, demographic and interview data, video interviews and newspaper articles—all invented— the students believed that they could recognize a real town that had been given a pseudonym:

> So this town has got to be such and such! … The students amuse me … because they come in and they know country towns! They know the answers, they know the people, and I just keep saying ‘Well that just shows that [the authors] actually did our homework.’ (Interview with Violet)

The same teacher noted that it did not matter to the students’ involvement in the scenario that the data was not from a real town:

> The data was real enough so that you would think it was real, and it becomes real. So within a couple of weeks they’ve shifted past the virtual and its real! (Interview with Violet)

Another teacher noticed that some of the students were so engaged in a scenario (based largely on text and cartoon sketched characters) that they were able to talk about one of the characters as if he was a real person:

> One day I walked in and the students were there in the lab … chatting to each other, and they were going on and on about this person they were having trouble with. I inquired about it and it turned out it was [one of the characters on the website]. I said as gently as I could ‘That’s not a real person, it’s a character’ and they said ‘We know that’. Then they just ignored me and kept conversing with each other about what an awful person he was, and how difficult they were finding him—as if he was real! (Interview with Brooke)

Engagement with the task appears to be of greater import to both teachers and learners than an exact replica of a real life learning situation, particularly for learning in higher education. Professional graphics and website design did not rate highly with any respondent in the study. One teacher pointed out that the original design for the website planned to include realistic graphics and photographs as a faithful reproduction of a real-world work environment. Instead, the website was tested with simple sketches:

> Our concern was that the sketches wouldn't seem as real to the students. When we piloted it, it worked sensationally. I suppose the students these days are so used to the blending of artificial and the real it didn't bother them at all. (Interview with Brooke)

The view expressed by one instructional designer about the quality of graphics, was one shared by many:

> If it were a commercial product, I'd be disappointed in some of the technology and the graphics that I think are low end. If we spent a bit more money on it we could have something that looked a lot more professional … but I think that is a relatively trivial point at the moment. Yes, I think it's been engaging; I think the students have learnt at a higher level … There is quite clear evidence that very large numbers of the students become deeply engaged. The evidence is overwhelming that the students mostly become very seriously committed to this scenario and they do find it deeply engaging. (Interview with Camille)

Just as the impact of a cognitive tool cannot be judged in isolation of its use and implementation (Steketee, 2002), these results indicate that realism in learning environments is not a premium requirement for engagement in isolation of the task performed by students and the context of its use.

Discussion

Numerous kinds and levels of institutions of higher education are integrating simulations into the teaching and learning environment. For example, Dede (2005) describes how simulations are being designed and used at Harvard University to meet the needs of what he calls 'neomillennial learning styles.' At arguably the other end of the academic spectrum, Oblinger (2004) describes how the University of Phoenix, a for-profit entrepreneurial institution that has more than 284,000 students enrolled either on its 180 physical campuses or in its more than 40 online degree programs, uses simulations in many courses, including in an MBA program.

The enthusiasm for using simulations in the college classroom should be tempered by the realization that matching a specific simulation with a specific learning need is not an easy task. Van Eck (2006) cautions that academics should not confound the message (content and instructional design) with the medium (digital game based learning or DGBL):

> Will we realize the potential that DGBL has to revolutionize how students learn? This has much less to do with attitude and learner preferences than it does with a technology that supports some of the most effective learning principles identified during the last hundred years. If we learn from our past, and if we focus on the strengths of the medium and provide the support and infrastructure needed to implement DGBL, we may well be present for a true revolution. (p. 30)

From the perspective of our research, the 'most effective learning principles' noted by Van Eck are aligned with the characteristics of authentic activities listed above. The challenge of matching a simulation with a learning need can be met when instructional designers and instructors collaborate to identify the types of authentic tasks that will align with other critical components of the learning environment such as goals and objectives, content, technological affordances, and assessment. The good news about our research is that the development and implementation of such learning environments in higher education do not require Hollywood budgets or sophisticated programming. Cognitive engagement can be realized without high fidelity immersive virtual reality technologies.

Conclusion

Immersive learning technologies in the form of realistic simulations are widely used in 'high stakes' learning settings such as space training, medical education and piloting. However, because these types of simulations are very expensive and resource-intensive to produce, their use in education generally has been limited. Those environments that have been created tend to focus on more achievable lower-order learning, such as demonstrations, opportunities to practice, and testing (Min, 2006). Quinn (2005) expands on the issue of fidelity or accuracy in learning simulations:

> Given that people are part of the equation, in simulation design, perfection is not always as perfect as you might hope. Part of the goal of any simulation is to focus the learner on a finite, not infinite, set of relationships. While the number of relationships will grow

> both as simulations become more powerful and as we become more used to learning from them, simulations will never reach the infinite subtlety of life, *nor should they* (p. 103, italics added).

In judging the impact of realism in online learning environments, we propose that the 'cognitive realism' of the task is of greater importance than the reality of the task or its realistic simulation. Our research has indicated that it is not necessary for learning environments to comprise resource-intensive virtual reality, or highly realistic simulations utilizing custom built projection rooms or visual and audio headsets (Green & Sulbaran, 2006) to be fully immersive.

We have found that the task itself is the key element of immersion and engagement in higher order learning. When appropriate technologies can be selected as required, and used as cognitive tools to solve complex problems, the responsibility for learning moves back to the learner, rather than the designer of the virtual environment. The learner is responsible for deciding the steps and sub-steps required to complete the task, and in so doing, the learning activities are more considered and reflective. The considerable affordances of web-based technologies, and the increasing availability and ease of use of image, video and audio technologies mean that learners can now readily create polished and meaningful products that reflect their own personal construction of knowledge. In this way, it is the learning environment and task that create the conditions for immersion, not the technologies themselves.

Acknowledgments

Our research collaboration has been partially funded by the Australian Research Council, the Australian-American Fulbright Commission, and our respective universities. With thanks to the dedicated and talented teachers and instructional designers and their teams who have shared their work with us.

References

Alessi, S. (1988). Fidelity in the design of instructional simulations. *Journal of Computer-Based Instruction, 15*(2), 40-47.

Barab, S. A., Squire, K. D., & Dueber, W. (2000). A co-evolutionary model for supporting the emergence of authenticity. *Educational Technology Research and Development, 48*(2), 37-62.

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-based learning: An approach to medical education*. New York: Springer.

Bransford, J.D., Vye, N., Kinzer, C., & Risko, V. (1990). Teaching thinking and content knowledge: Toward an integrated approach. In B.F. Jones & L. Idol (Eds.), *Dimensions of thinking and cognitive instruction* (pp. 381-413). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Cognition and Technology Group at Vanderbilt. (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher, 19*(6), 2-10.

Dede, C. (2003). Multi-user virtual environments. *EDUCAUSE Review*, *38*(3), 60-61.

Duchastel, P.C. (1997). A Web-based model for university instruction. *Journal of educational technology systems, 25*(3), 221-228.

Fosnot, C. T. (Ed.). (2005). *Constructivism: Theory, perspectives and practice* (2nd ed.). New York: Teacher's College Press.

Gordon, R. (1998). Balancing real-world problems with real-world results. *Phi Delta Kappan, 79*, 390-393.

Green, M.E., & Sulbaran, T. (2006). Preview of using distributed virtual reality in construction scheduling education. In T.C. Reeves & S.F. Yamashita (Eds.), *Proceedings of ELearn Conference 2006* (pp. 51-56). Chesapeake, VA: AACE.

Greenhalgh, M. (2002). Learning art history in context: A model of Borobudur and the limits of reality. *The Journal of Education, Community and Values: Interface on the Internet, 2*(6), 1-14. Online journal: http://www.bcis.pacificu.edu/journal/2002.

Herrington, J., & Herrington, A. (1998). Authentic assessment and multimedia: How university students respond to a model of authentic assessment. *Higher Education Research and Development, 17*(3), 305-322.

Herrington, J., Reeves, T. Oliver, R., & Woo, Y. (2004). Designing authentic activities in web-based courses. *Journal of Computing and Higher Education, 16*(1), 3-29.

Jonassen, D. (1991). Evaluating constructivistic learning. *Educational Technology, 31*(9), 28-33.

Kay, A. (1991). *Computers, networks and education*. Retrieved October 19, 2006 from http://www.artmuseum.net/w2vr/archives/Kay/Computers.html .

Lebow, D., & Wager, W.W. (1994). Authentic activity as a model for appropriate learning activity: Implications for emerging instructional technologies. *Canadian Journal of Educational Communication, 23*(3), 231-144.

Macedonia, M.R., & Rosenbloom, P.S. (2001). Entertainment technology and virtual environments for training and education. In M. Devlin, R. Larson , & J. Meyerson (Eds.), *The internet and the university: 2000 forum* (pp. 79-95). Boulder, CO: EduCause.

McLellan, H. (1991). Virtual environments and situated learning. *Multimedia Review, 2*(3), 30-37.

Miles, M.B., & Huberman, A.M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd. ed.). Thousand Oaks, CA: Sage.

Min, R. (2006). Methods of learning in simulation environments. In C. Juwah (Ed.), *Interactions in online education: Implications for theory and practice* (pp. 117-137). London: Routledge.

Murray, C., & Cox, C. (1989). *Apollo: The race to the moon*. New York: Simon and Schuster.

Murnane, J. (2000). Simulating reality: mouse-clicks or bottle-tops? Retrieved October 1 2006 from http://www.ifip.org/con2000/iceut2000/iceut10-06.pdf

Myers, S. (1993). A trial for Dmitri Karamazov. *Educational Leadership, 50*(7).

Oblinger, D. G. (2004). The next generation of educational engagement. *Journal of Interactive Media in Education, 8,* 1-18.

Oliver, R., & Omari, A. (1999). Using online technologies to support problem based learning: Learners responses and perceptions. *Australian Journal of Educational Technology, 15*(158-79).

Quinn, C. (2005). *Engaging learning: Designing e-learning simulation games*. San Francisco: Pfeiffer.

Rabkin, M.T. (2002). Patient simulators: Is it real or is it ultrasim? *Prospective, 1*(3), Available: http://www.bidmc.harvard.edu/prospective/vol1/ver3/sims.asp.

Reeves, T.C., & Okey, J.R. (1996). Alternative assessment for constructivist learning environments. In B.G. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design* (pp. 191-202). Englewood Cliffs, NJ: Educational Technology Publications.

Rist, R. (1973). *The urban school: A factory for failure*. Cambridge, MA: MIT Press.

Rosenberg, M. J. (2006). *Beyond e-learning*. San Francisco: Pfeiffer.

Savery, J.R., & Duffy, T.M. (1996). Problem based learning: An instructional model and its constructivist framework. In B.G. Wilson (Ed.), *Constructivist learning environments: Case studies in instructional design* (pp. 135-148). Englewood Cliffs, NJ: Educational Technology Publications.

Smith, P. (1986). *Instructional simulation: Research, theory and a case study* [ED 267 793].

Smith, P.E. (1987). Simulating the classroom with media and computers. *Simulation and Games, 18*(3), 395-413.

Steketee, C. (2002). Students' perceptions of cognitive tools and distributed learning environments. In A. Goody, J. Herrington, & M. Northcote (Eds.), *Quality conversations: Research and Development in Higher Education, Volume 25* (pp. 626-633). Jamison, ACT: HERDSA.

Sternberg, R.J., Wagner, R.K., & Okagaki, L. (1993). Practical intelligence: The nature and role of tacit knowledge in work and at school. In J.M. Puckett & H.W. Reese (Eds.), *Mechanisms of everyday cognition* (pp. 205-227). Hillsdale, NJ: Lawrence Erlbaum Associates.

Van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless. *EDUCAUSE Review,* 41(2), 16–30.

Young, M.F. (1993). Instructional design for situated learning. *Educational Technology Research and Development, 41*(1), 43-58.

Young, M.F., & McNeese, M. (1993). A situated cognition approach to problem solving with implications for computer-based learning and assessment. In G. Salvendy & M.J. Smith (Eds.), *Human-computer interaction: Software and hardware interfaces*. New York: Elsevier Science Publishers.

Author bios

Jan Herrington, PhD, is Associate Professor in IT in Education at the University of Wollongong, Australia. Recent research and development interests have focused on the design of web-based learning environments for higher education and the use of authentic tasks as a central focus for web-based courses. She was awarded the Association of Educational Communications and Technology (AECT) *Young Researcher of the Year Award* in Houston in 1999 and won a Fulbright Scholarship in 2002 to conduct research at the University of Georgia, USA. The authentic tasks webpage (developed with Tom Reeves and Ron Oliver) can be accessed at: www.authentictasks.uow.edu.au.

Thomas C. Reeves is a Professor of Instructional Technology at The University of Georgia. After completing his PhD. at Syracuse University in 1979, he spent a year as a Fulbright lecturer in Peru. His research interests include evaluation of instructional technology, socially responsible educational research, mental models and cognitive tools, authentic learning models, and instructional technology in developing countries. In 2003, he was the first person to receive the *AACE Fellowship Award* from the Association for the Advancement of Computing in Education. His *Interactive Learning Systems Evaluation* book (with John Hedberg) was published in 2003. His URL is: http://it.coe.uga.edu/~treeves/

Ron Oliver, PhD, is the Foundation Professor of Interactive Multimedia at Edith Cowan University in Western Australia. He has wide experience in the design, development, implementation and evaluation of technology-mediated and online learning materials. He uses technology extensively in his own teaching and his ideas and activities are all typically grounded in practical applications. Ron has won a number of awards for his innovative teaching and research including the inaugural *Australian Award for University Teaching* for the use of multimedia in university teaching. His URL is http://elrond.scam.ecu.edu.au/oliver